Using Collaborative Activities on Tabletops to Enhance Learning and Knowledge Transfer

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***Abstract*—Digital tabletops are gaining increasing relevancy within commercial and educational sectors. These devices, with their multi-touch surfaces, can support collaborative activities while maintaining natural face-to-face communication. However, we still know little about possible learning outcomes and the situations they favor. We have conducted a study to explore how group activities on tabletops could potentially encourage collaboration on tabletops. We have particularly focused on the potential of tabletops to favor knowledge transfer, which can be translated to the question how knowledge might be assimilated, understood and transferred in the best way. This paper presents a comparative study of a learning session using concept-maps on tabletops and a learning session using traditional paper and pencil tools. The comparison revealed a tendency for the tabletop-environment to effectively support knowledge transfer.**

CSCL, collaborative learning, motivation and engagement in Technology-enhanced Learning & Education, tabletop, brainstorming, concept-map

I. Introduction

Over the last fifteen years, educational games have been playing an important role in framing the learning of complex methods [1]. Set into typical computer-supported collaborative learning (CSCL) environments (for an overview see [2]), students have to learn and use knowledge to progress in the game. While these serious games emphasize students' motivation, working experiences over the previous fifteen years illuminate that problems often occur when it comes to transfer their knowledge to real case scenarios (e.g. [3]). This paper will show that these difficulties may well stem from a distinct lack of tools available in the game in order to step back, reflect upon their actions and to understand the whole process to learn. In light of this, we address the issue of knowledge transfer by integrating concept-maps (e.g. [4]) into the usual learning process. We will show that using this type of tool on tabletops might outperform its traditional paper-pencil version. Although educational games were our starting point, this factor will not form part of our study, rather than the given context to which we come back in our conclusion.

II. Theoretical Framework

A. CSCL (Computer-Supported Collaborative Learning)

In the last twenty years, there have been many attempts to favor and support interactions in CSCL environment. Crook [5] depicted four types of interaction: 1) interactions at computers, 2) interactions around computers, 3) interactions related to computer applications, and 4) interactions through computers. While the former three types of interaction foster face-to-face situations, including mimic and gesture, most of the time learners in a CSCL environment face the latter type of interaction. Undeniably, face-to-face situations should be favored, especially when it comes to the construction of shared representations of complex subjects, or problem solving tasks [6]. With tabletops, a promising technology occurred to enable multiple users to share one computer, while preserving natural communication habits.

B. Tabletops

In 2004, Rogers and Lindley [7] showed that a comparison between collaborative learning on a tabletop and collaborative learning in front of a shared screen confirmed a preference for the tabletop to enhance argumentation and articulation. As a result, many different tabletops have been developed in the last few years, such as InteracTable [8], DiamondTouch [9] or UbiTable [10], to study either the user interface and applications ([8], [9]) or different facets of the technological possibilities ([10]). In our work, we decided to take advantage of this technological and collaborative possibility.

C. Concept Mapping

Visual representation tools are often used in CSCL environments. Most notably, concept-maps have emerged as an effective means of supporting students in understanding complex subjects and in building actively logic representations [11]. When concepts-maps are constructed in collaboration, they are useful to support students in articulating and verbalizing the problem, often leading to a more elaborated solution. As our goal is to provide a means that enables students to realize the "when" and "why" a tool or method have to be applied, we decided to use "flowcharts" as concept-maps which is in line with findings of Fischer *et al.* [6] and Slof *et al.* [12]. In the next section, we detail the research question, providing an overview of a requirement analysis we conducted before the experiment, present our tabletop application and provide insight into the methodology of our comparative study.

III. Research Issues and Methods

A. *Research Question*

Designing the study had two research goals: on the one hand, we liked to know if using a concept-map-tool permits to achieve better learning outcomes in performing a certain task (learning the procedure of a brainstorming, while performing a brainstorming). On the other hand we hypothesized that using the concept-map-tool in a tabletop CSCL environment would outperform the usage in a traditional manner. The development of our application is based on eight guidelines formulated by Scott, Grant & Mandryk [13]. To refine these guidelines, we performed a requirements analysis.

B. *Requirements Analysis*

In line with the "User Centred Design" (UCD) [14] qualitative studies illuminated, firstly, the need for a tool (within the game) which serves to increase students' knowledge beyond what is necessary and create a space for analysis and reflection on their own actions in a more effective way. Secondly, the notions of "briefing" and "debriefing" that are embedded respectively before and after the brainstorming session as a first means of reflection, had to be upheld. Thirdly, in presenting two different paper-prototypes to a focus group, we concluded that usual multitouch interactions overrule possible tangible object interactions. Together with two experienced tutors, we decided to introduce an exercise based on the notion of a "cloze" in the debriefing phase, where participants are asked to bring the right actions into the right order. Garnering these observations, we started designing our application.

C. *Application design*

1) *Tabletop Application*

In this research, we use specific tables designed in our laboratory [15]. With two HCI-experts, a particular software was developed for the experiment. Just as during a paper-pencil brainstorming learning session, Post-its and a whiteboard were implemented. The goal was to keep the appearance and interactions as simple and intuitive as possible: digital Post-its resembled real Post-its, with the functionality to write and paint via a virtual keyboard or by finger-painting. The whiteboard was a large white screen, proposing similar functionalities including the possibility for the students to add their own Post-its onto the board. The whiteboard acted as a global shared space where every action on one whiteboard (one tabletop) was immediately reflected on all other whiteboards (other tabletops). We implemented classical tactile interactions such as one-finger-touch, one-finger-drag, as well as pan-gestures for zoom-in and zoom-out events.

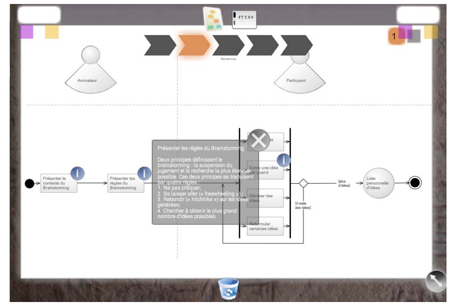

Figure 1. Concept-map and information tool

2) *Support for knowledge transfer*

The concept-map-tool in the traditional paper version consisted of four diagrams: one process-chart and three flowcharts. The process-chart served as an overview. Each flowchart had two layers of information (primary and secondary) which were indicated by lines of different styles. In addition, we provided a three-page-documentation of the flowcharts, describing each action in the diagram.

The digital version used the same appearance of the flowcharts as the paper version, but allowed to dynamically switch between the layers of information. It provided the information of each action inside the chart by dynamically displaying an information overlay window, rather than an extra document (Fig. 1).

D. *Comparative Study*

The study consisted of three conditions. A control group (Group 1) of eight participants performed a brainstorming session without concept-maps and in a traditional paper-pencil manner, using Post-its and a whiteboard. The second condition (Group 2), a group of eight participants, was a brainstorming session in the traditional manner, but extended with a paper-version of our concept-map-tool, including information material, while in the third condition (Group 3) six participants[1] were asked to perform the brainstorming session using our concept-map-tool exclusively on the tabletop. Instead of a verbal debriefing, participants in the second and third condition had to solve a "cloze"-task, thus bringing all actions of the concept-map into the right flow.

Overall, 22 students (of which 7 women and 15 men) were recruited and were randomly assigned to the groups. All groups were guided by three tutors who followed a strict guideline that had been developed in advance to define the content and duration of each step. Step 1 was to fill out a pre-test of five free-answer questions gathering the participants' general knowledge about the brainstorming (5-10 minutes). Step 2 was to brief the group on the general cycle of the experiment, the most important phases and the general rules of a brainstorming (10 minutes). Step 3 was practicing the brainstorming by introducing the topic ("Imagine your future car"), and by going through three phases: 1. Anonymously generating ideas and annotating each on a Post-it; 2. Collaboratively categorizing or rejecting ideas on the

[1] The experiment was designed for 4 tabletops shared by 2 users (8 participants for each condition) but for technical reasons, we were able to use only 3 tabletops (6 participants for Group 3).

whiteboard; 3. Collaboratively generating more ideas, based on the ideas left on the whiteboard (30 minutes). Step 4 was a debriefing to reflect on the brainstorming-session (5-10 minutes), followed by step 5: a post-test with 10 questions (containing the 5 questions of the pre-test, 4 new free-answer-questions and one problem solving task) (20 minutes).

IV. Results and Discussion

All groups showed a learning gain after the brainstorming session, the groups with access to our concept-map-tool performed slightly better, than without. Post-test comparison revealed a tendency for the tabletop-group to be more favorable.

The analysis for the learning outcome comparison verified the tendency for the condition using concept-maps on tabletops (Group 3) as the most supportive, significantly at odds with the control group. It is interesting to note that the condition using the paper-version of the tool (Group 2) was not as supportive as the version on tabletops.

These results are encouraging despite some of the problems we detected using usability tests. The application could be improved in order to limit misunderstanding or misconception. In addition, a further development might increase the quality of certain parts of the application to be even more adaptable to a horizontal interface, as the digital whiteboard or even the concept-map-tool itself still appears like their analogical equivalent.

V. Conclusion and Further Issues

Our experiment showed a tendency that knowledge transfer with concept-map visualizations in collaborative learning activities might be increased using tabletops.

Concerning the experiment, we plan to extend the sample size, to increase the interface quality, and to refine our analysis by using a combination of qualitative and quantitative settings. As Do-Lenh *et al.* [16] observed, it is equally or even more important to analyze human interactions with each other, as with the technological environment, as it might permit to gain insight into the cognitive process (reflection, elaborated explaining, articulation and argumentation), and therefore, into a potential knowledge transfer. We verified with our experiment, that concept-map-tools can be a good means for the learners to reflect on their actions. This should be tested in a broader context, conceptualizing, for example, small educational games, with several lessons to accomplish, which integrates similar concept-map-tools. Based on the present study, we see great potential in implementing tabletop-technology and such tools to improve knowledge transfer in educational games.

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References

[1] I. Akkouche, & P. Prévot, “Cooperative distance learning-sessions management: A transportation model application to Role Distribution”, Proceedings of the International Conference on Industrial Engineering and Production Management, Lyon, France, 1997, pp. 166-174.

[2] L. Lipponen, Exploring foundations for computer-supported collaborative learning. Proceedings of the Conference on Computer Support for Collaborative Learning, International Society of the Learning Sciences, CSCL, 2002, pp. 72–81.

[3] J.E. Korteling, A.S. Helsdingen, R.R. Sluimer, M.L. van Emmerik & B. Kappe, “Transfer of Gaming: Transfer of training in seriousgaming”, TNO report, August 2011, 52 p.

[4] J.M. Spector, “Cognition and learning in the digital age: Promising research and practice” Computers in Human Behavior Volume 24, Issue 2, March 2008, pp. 249-262.

[5] C. Crook, Computers and the collaborative experience of learning. Routledge, 1996, 261 p.

[6] F. Fischer, J. Bruhn, J. Gräsel, & H. Mandl.. “Fostering collaborative knowledge construction with visualization tools. Learning and Instruction”, 12(2), 2002, pp. 213-232.

[7] Y. Rogers, & S. Lindley, “Collaborating around large interactive displays: which way is best to meet.” Interacting with Computers, 16(6), 2004, pp. 1133–1152.

[8] N. A. Streitz, J. Geißler, T. Holmer, S. Konomi, C. Mu□ller-Tomfelde, W. Reischl, P. Rexroth, *et al.*, “i-LAND: an interactive landscape for creativity and innovation.” Proceedings of the SIGCHI conference on Human factors in computing systems, CHI ’99, Pittsburgh, Pennsylvania, US, ACM, 1999, pp. 120–127.

[9] P. Dietz, & D. Leigh, “DiamondTouch: a multi-user touch technology.” Proceedings of the 14th annual ACM symposium on User interface software and technology, UIST ’01 ,Orlando, Florida: ACM, 2001, pp. 219–226, doi:10.1145/502348.502389

[10] C. Shen, K. M. Everitt, & K. Ryall, “UbiTable: Impromptu face-to-face collaboration on horizontal interactive surfaces”. Proc. of UbiComp'03, 2003, pp. 281-288.

[11] S. N. Demetriadis, P. M. Papadopoulos, I. G. Stamelos, & F. Fischer. "The effect of scaffolding students’ context-generating cognitive activity in technology-enhanced case-based learning”. Computers & Education, 51(2), 2008, pp. 939-954, doi:16/j.compedu.2007.09.012

[12] B. Slof, G. Erkens, P. A. Kirschner, J. Janssen, & C. Phielix, “Fostering complex learning-task performance through scripting student use of computer supported representational tools”. Computers & Education, 55(4), 2010, pp. 1707-1720.

[13] S. D. Scott, K. D. Grant, & R. L. Mandryk, “System Guidelines for Co-located, Collaborative Work on a Tabletop Display”. PROC. ECSCW 2003, 2003, pp. 159-178.

[14] ISO - International Organization for Standardization, & ISO – International Organization for Standardization. (n.d.). ISO - International Organization for Standardization. Text, . Retrieved August 3, 2011, from http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=38009

[15] F. Delomier, B. David, R. Chalon, F. Tarpin-Bernard “Place de la réalité mixte dans les Serious Games”, Workshop “Interfaces avancées pour l'apprentissage”, Conférence EIAH’2011, Mons, Belgique, May 2011, pp. 45-52.

[16] S. Do-Lenh, F. Kaplan, & P. Dillenbourg, “Paper-based concept map: the effects of tabletop on an expressive collaborative learning task”. Proceedings of the 23rd British HCI Group Annual Conference on People and Computers, BCS-HCI ’09, Cambridge, United Kingdom: British Computer Society, 2009, pp. 149-158.